Claims

1. A rate adaptive pacemaker comprising a means (2) for determining the demand of a patient's organism, a pacing rate controlling means (16) for controlling the pacing rate in response to the patient's demand, and a pacing rate limiting means (14) for preventing the pacing rate from becoming too high, said pacing rate limiting means (14) being adapted to limit the pacing rate upwards such that a predetermined relation is maintained between energy supplied to the myocardium and energy consumed by the myocardium, and including an upper limit setting means (12) for setting an upper limit value for the pacing rate, and an upper limit determining means (10) for determining the relation between energy supplied to the myocardium and energy consumed by the myocardium for calculating an upper pacing rate limit value from said relation for supply to said upper limit setting means (12), **characterized in** that said pacing rate limiting means (14) is adapted to limit the pacing rate upwards such that the energy consumed by the myocardium always is less than energy supplied to the myocardium.

2. The pacemaker according to claim 1, **characterized in** that said pacing rate limiting means is adapted to limit the pacing rate such that the inequality

$$(t_{diast,rest}/t_{diast})\cdot(SV/SV_{rest}) < CR$$

is satisfied, where $t_{diastrest}$ denotes diastolic duration for the patient in rest conditions, t_{diast} actual diastolic duration for the patient, SV and SV_{rest} actual stroke volume and stroke volume for the patient in rest conditions respectively, and CR the coronary reserve.

3. The pacemaker according to claim 1 or 2, **characterized in** that said upper limit determining means (10) includes an energy determining means for determining the energy supplied

to the myocardium and the energy consumed by the myocardium respectively, and a comparison means for comparing supplied energy and consumed energy for determining said relation.

4. The pacemaker according to claim 3, **characterized in** that said energy determining means is adapted to determine consumed energy as the product of mean value of ventricular pressure variations during a cardiac cycle and stroke volume.

5. The pacemaker according to claims 3 or 4, **characterized in** that said energy determining means is adapted to determine supplied energy from the time response curve of the arterial pressure during diastole.

6. The pacemaker according to claim 5, **characterized in** that said upper limit determining means (10) is adapted to determine actual coronary resistance ratio (CRR) from the equation

supplied energy = consumed energy

and determine an upper pacing rate limit value from the relation between actual coronary resistance ratio (CRR) and coronary reserve (CR).

7. The pacemaker according to any of the claims 1-6, **characterized in** that said upper limit determining means is adapted to determine the upper pacing rate limit value from the equation

$$\text{upper pacing rate limit} = (60 \cdot CR) / [t_{diast,rest} \cdot (SV/SV_{rest}) + CR \cdot t_{syst}]$$

where CR denotes the coronary reserve, $t_{diastrest}$ diastolic duration for the patient in rest conditions, SV and SV_{rest} actual stroke volume and stroke volume for the patient in rest conditions respectively, and t_{syst} the actual systolic duration.

8. The pacemaker according to any of the claims 2-7, **characterized in** that a bioimpedance measurement unit is

provided to measure the intracardiac bioimpedance as a function of time and determine therefrom actual stroke volume SV and actual diastolic or systolic durations t_{diast} or t_{syst} respectively.

9. The pacemaker according to any of the claims 2-7, **characterized in** that an ECG measuring and analyzing unit is provided to measure ECG and determine therefrom actual stroke volume SV and actual diastolic or systolic durations t_{diast} or t_{syst} respectively.